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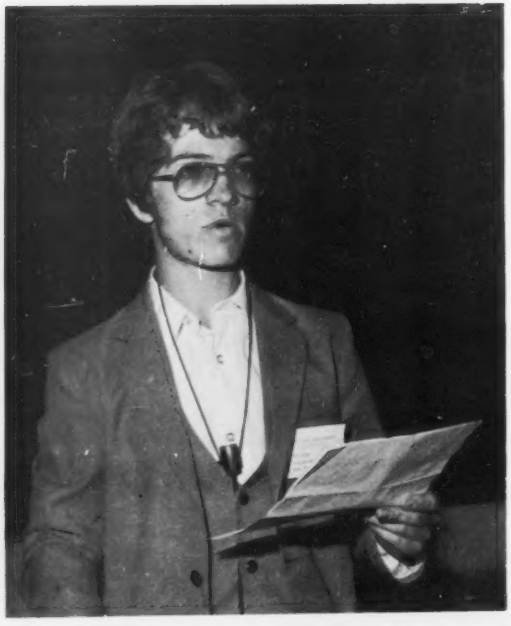
About the Cover

Todd Nelson, one of 10 winners of NASA's first Space Shuttle Student Involvement Project, watches as NASA photographer Don Yeates adjusts the data acquisition camera that wil be part of Nelson's experiment flying on board the third Space Shuttle flight, scheduled for launch March 22. Honeywell Avionics Division, Minneapolis, is the corporate sponsor of Todd's experiment which studies the affect of weightlessness on the flight of insects.

Below, Todd answers queries at an STS-3 experiments briefing held at Johnson on Feb. 25. Todd is an 18-year old senior from Southland Public School, Adams, Minn. His entry for the 1980-81 contest was among 1,500 entries submitted.



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Student Experiment to Fly on Third Shuttle Mission

The third flight of NASA's Space Shuttle, scheduled for launch March 22, will have an exceptional meaning for a high school student from Rose Creek, Minn. He will have a scientific experiment flying on it. The experiment, "Insects in Flight Motion Study," was devised by Todd E. Nelson, an 18-year-old senior from Southland Public School, Adams, Minn., one of 10 finalists in the first national Space Shuttle Student Involvement Project.

The Shuttle Student Involvement Project for Secondary Schools is a joint venture of NASA and the National Science Teachers Association and is designed to stimulate the study of science and technology in the nation's secondary schools.

The insects to be examined are the velvetbean caterpillar moth and the honeybee drone. The object of the experiment is to study these two species under uniform conditions of light, temperature and pressure; the variable being the absence of gravity in space.

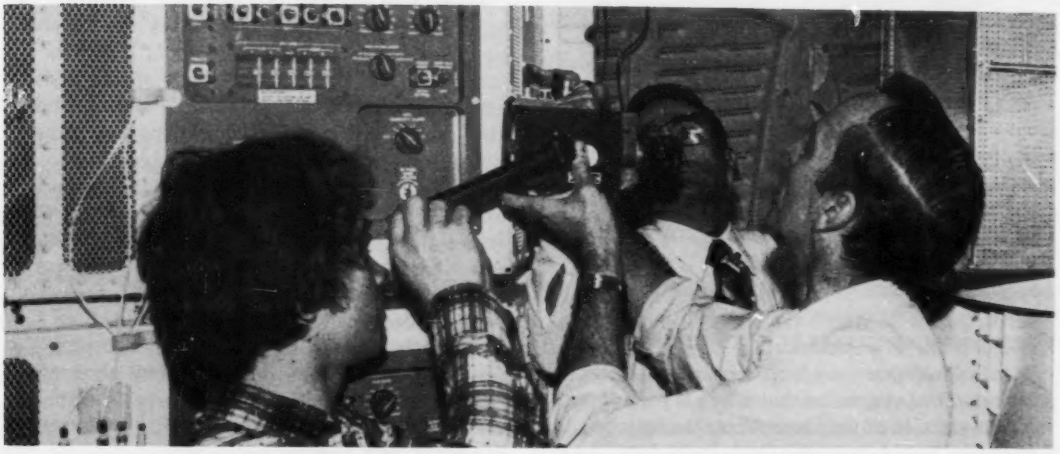
The experiment will focus on the flight behavior in zero gravity of two species of flying insects with differing ratios of body mass to wing area. Gravitational force is of primary importance for orientation and stable free flight of insects. The experiment will provide new aspects to research on responses of flying insects to changes in gravity which has been worked on at NASA's Ames Research Center, Mountain View, Calif.

Ten insects of each species will be carried in separate canisters, which will be stored in a Shuttle locker. The crew of the Space Shuttle (Jack Lousma and Gordon Fullerton) will remove the canisters from the storage locker and attach them to the mid-deck wall where they will observe the insects and film them with a data acquisition camera as the insects' behavior adapts to the zero gravity environment.

To broaden participation in the Shuttle Student Involvement Project, NASA solicited U.S. industrial firms and other groups to sponsor the development of the student experiments. Sponsors were asked to assign a company scientist to work with the student; fund the development of the experiment, including necessary hardware; provide travel funds to take the student to appropriate NASA installations during experiment development; and give the student assistance in analyzing post-flight data and preparing a final report.

The Avionics Division of Honeywell, Inc., of Minneapolis, agreed to sponsor Nelson's insect experiment. During the past six months Nelson has worked with Robert Moulton and Dr. Robert Peterson at Honeywell's headquarters to ready the experiment for flight.

Others who have assisted Nelson in this project are Robert D. Roberts, his teacher-advisor, and Dr. Bill Williams of the Biosystems Division at Ames Research Center. Assisting with Shuttle payload integration was Chris Perner and John Jackson of the Crew Integration Section, NASA Johnson Space Center, Houston.



Todd Nelson looks through the lens of the data acquisition camera to be used when his experiment flies aboard the Columbia. NASA photographer, Don Yeates, holds the camera and in the background John Jackson of NASA's flight integration office assists.

Third Shuttle Prime Experiments

Key experiments carried aboard the third flight of the Space Shuttle Columbia include: OSS-1 (for the Office of Space Science), a payload which consists of nine different experiments; the electrophoresis experiment verification test; monodisperse latex reactor; induced environment contamination monitor; catalytic surface effects experiment; dynamic acoustic and thermal environment experiment; getaway special verification payload; and the Heflex bioengineering test. Following are synopses of these key experiments sheduled for flight March 22.

OSS-1

The primary payload carried aboard the third Space Shuttle flight is OSS-1 (for Office of Space Science). Most of the OSS-1 scientific equipment will be mounted on a pallet designed and provided by the European Space Agency. The experiments will check factors that cannot be pretested on Earth but that may affect future scientific work on board the Shuttle. These include reactions of orbiter and payload to thermal variations greater than ever experienced on Earth; effects of an orbiter-generated "cloud" of particles and gases, if any; and the degree of electrical charging on the spacecraft.

The experiments which make up the OSS-1 payload are: plasma diagnostics package, vehicle charging and potential, Shuttle Spacelab induced atmosphere, solar ultraviolet spectral irradiance monitor, solar flare x-ray polarimeter, contamination monitor package, microbrasion foil experiment, thermal canister, and plant lignification in weightlessness.

The **Plasma Diagnostics Package** (PDP) experiment will define the electromagnetic environment around the orbiter at its parking-orbit altitude in the plasma. The orbiter is a much larger spacecraft than those used in the past for field measurements and as such its package is liable to distort electromagnetic fields and plasmas, leaving a wake in the ionosphere. The PDP will attempt to understand the wakes formed by various orbiter attitudes so that future plasma measurements can be interpreted accurately.

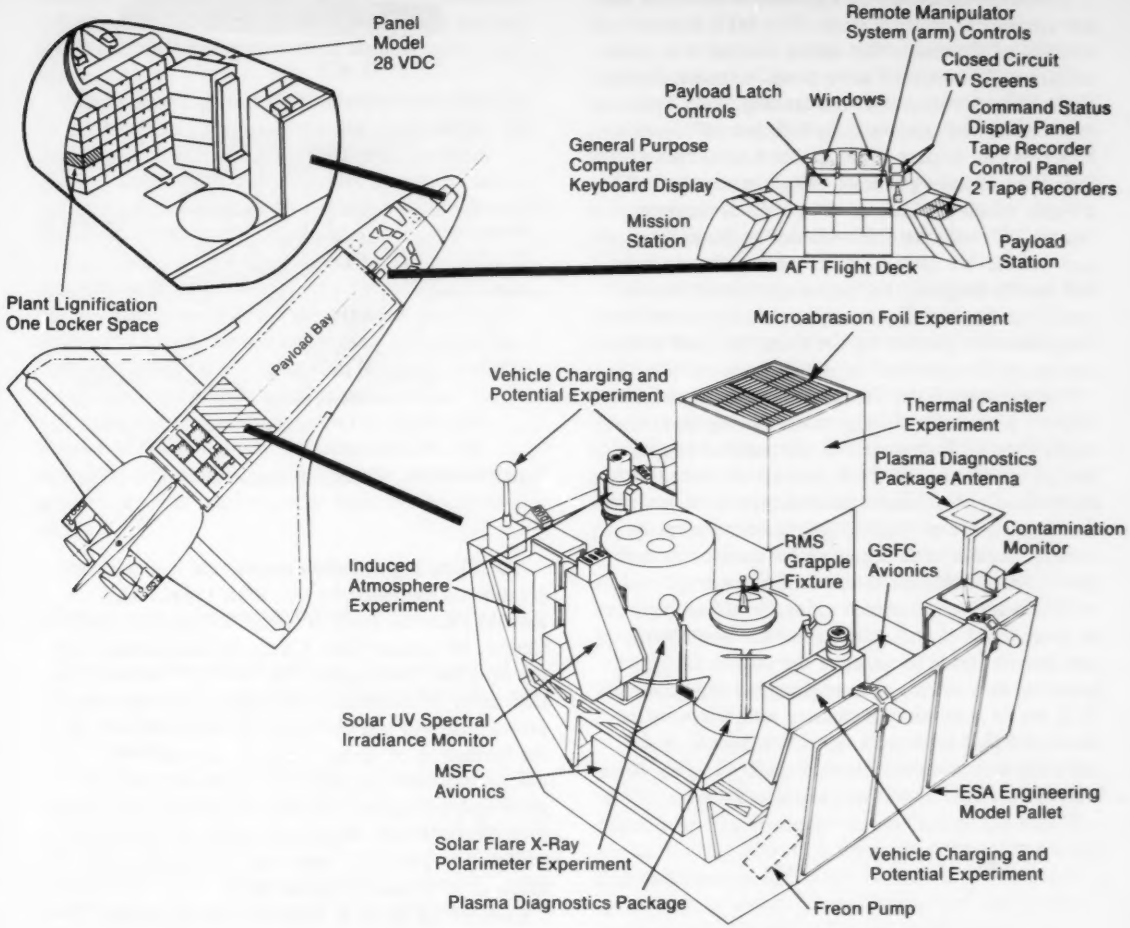
It is believed that the orbiter's speed should cause a bow shock analogous to that which is formed on the sunward side of the Earth where the solar wind compresses Earth's magnetic field. In the latter case, it is the medium that is moving, whereas with the Shuttle, it is the vehicle that is moving, but the physics are similar. The orbiter is expected to generate low-level dc magnetic fields from the 28 V power system and dc electric fields from its motion through the ionized plasma. These fields and resulting acceleration of particles will be measured.

The STS-3 crew will maneuver the Remote Manipulator System to grapple the PDP, unlatch it, and move it around the predetermined sweeps to map the orbiter's fields in and near the cargo bay and out to 15 meters distance, the longest reach of the arm. Then the PDP will be restowed for return to Earth.

The **Vehicle Charging and Potential** experiment will study electrification phenomena by inducing changes in electrical potential in a controlled manner. Part of the experiment is the first low-power Fast-Pulse Electron Gun to be used in space. Pulses will be varied in duration and emitted at varying repetition rates. The beam width will be in the range of 5-10 degrees. Two charge and current probes, mounted on diagonally opposite corners of the pallet, may react like the orbiter's surfaces. The sensors will record electrical effects that may be like those on the orbiter itself.

The **Shuttle-Spacelab Induced Atmosphere** will define the optical properties of an orbiter-induced atmosphere. A similar experiment with an identical instrument was conducted on Skylab; no contaminants could be found in a direction of 90 degrees to the Sun down to approximately a factor of 100 below the visible threshold. The orbiter may be equally clean. The twin of the Skylab instrument to be flown on OSS-1 includes two elements: a photoelectric polarimeter to measure the intensity of light and its polarization in 10 colors between 400 and 820 nanometers; and a bore-sighted 16-mm camera for concurrent photography of star fields to establish the instrument's pointing direction. The instrument will be operated by sweeping fore and aft through the orbiter's vertical axis.

The purpose of the **Solar Ultraviolet Spectral Irradiance Monitor** (SUSIM), which will be flown several times, is to improve the accuracy of far-ultraviolet flux measurements to some 10 percent or better between 140 and 210 nm by comparing these fluxes to the relatively stable fluxes above that wavelength. The SUSIM contains two complete observing systems. One makes constant observations; the second takes only a brief glimpse of the Sun once a day to check that the other has not been blinded. It will scan the solar spectrum between 120 and 400 nm with a spectral resolution of 0.1 nm. Ultraviolet, absorbed in the outer reaches of Earth's



Payload configuration for the OSS-1 experiments to be flown aboard the third flight of the Space Shuttle Columbia.

atmosphere, plays an important role in determining the physical properties of the upper atmosphere and, by implication, in influencing the condition of the lower levels that affect human life and livelihood.

The **Solar Flare X-ray Polarimeter** experiment is composed of three analyzers which will produce the most thorough sampling of flare X-rays ever made. Heretofore, because of the limited capacity of satellites, only one such analyzer could be flown at a time. This 3-unit device will register the scattering of a beam of incident photons. The redundant, cross-referenced data should provide an unambiguous decision. The data collected from this experiment will help scientists understand the polarization of X-rays emitted during a solar flare and provide a major advance in understanding the physical processes that drive solar flares.

The **Contamination Monitor Package** will assess the mass buildup of condensible volatile materials on surfaces in the Shuttle bay during all phases of ascent; and correlate mass buildup with payload activities, Shuttle operational events, OSS-1 instrument performance degradation and Induced Environment Contamination Monitor results. Correlation with other pallet instrumentation can provide valuable insight as to how molecular contamination affects instrument performance.

The **Microabrasion Foil Experiment** (MFE) is an extraterrestrial material study. The MFE is constructed of aluminum foil sheets bonded to a plastic substrate. These sheets are exposed to space during flight and examined after the landing. Very light particles cannot penetrate the foil, but will form a hypervelocity impact crater on the foil surface. Somewhat heavier particles will penetrate the foil to a depth which depends on the particle's incident velocity. Heavier particles will not be fragmented and will survive almost intact, whereas icy particles will readily fragment to form a number of impact craters in the rear Kapton sheet. An analysis of the fragmentation profiles on the sheet will yield information on the particles' densities.

The purpose of the **Thermal Canister Experiment** is to try a method of temperature management that might keep all instruments in the payload bay in a benign condition. The TCE canister contains five elements: fixed conductance heat pipe for equalizing the temperature of the interior canister walls; variable conductance heat pipe for controlling heat flow from the interior to external radiators, radiators and radiator heat pipes for discarding heat to space; control and data acquisition electronics; and heaters inside to simulate the output of typical scientific instruments. The engineering objectives for TCE are to maintain the canister wall temperature between 5 and 25 degrees C, ±3 degrees C; and maintain control with internal heat loads from 100 watts in sunlight to 400 watts in shade.

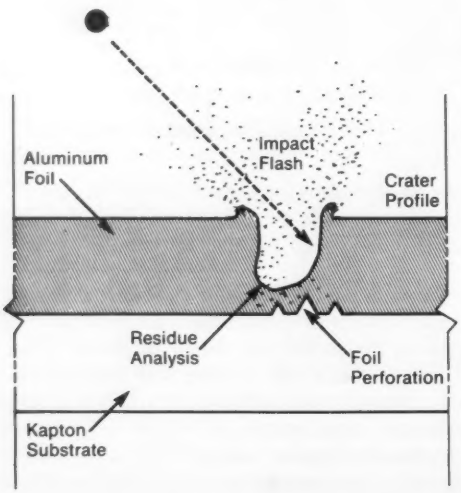


Diagram illustrating particle impact on OSS-1 Microabrasion Foil Experiment.

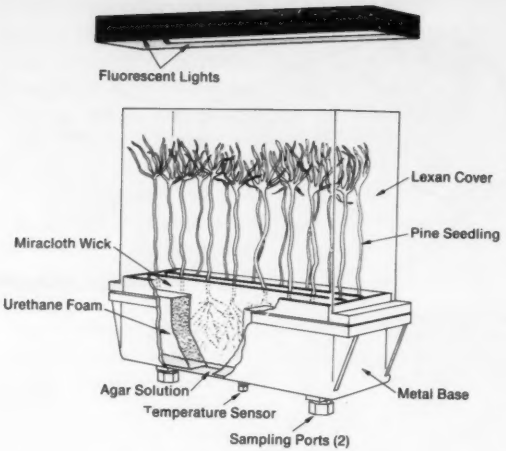


Illustration of OSS-1's Plant Lignification experiment.

The **Plant Lignification** experiment is a compact greenhouse managed by Dr. John Tremor and Ronald Mancini, both of NASA's Ames Research Center, Mountain View, Calif., in conjunction with the principal investigator, Dr. Joe R. Cowles of the University of Houston. The flight of the orbiting greenhouse will test the effect of weightlessness on the formation of lignin in plants. Lignin is the woody substance in plants which allows them to grow upward against the pull of gravity, gives them their characteristic shapes and supports the organs which carry food and chemicals. It makes up as much as 30 percent of plant tissue.

Controlling lignin is economically attractive because lignin interferes with extraction of wood fibers for the production of paper and plastics. In many plants it also competes with food production. Gravity appears to be a fundamental stimulus for the production of lignin. By comparing Earth-grown and space-grown plants, scientists hope to better understand the development of lignin and to some day learn to regulate it. Scientists believe that lignin production will decrease in space, but that plants still will grow upward in response to the growth unit's artificial sunlight. They are not sure how roots, less responsive to light, will grow. U.S. scientists have not had the opportunity to test their theories in the weightless environment of space.

A total of 96 plants will be carried aboard the orbiter Columbia in six 25-centimeter (10-inch) plant growth chambers. Oat and mung bean seeds and young slash pine seedlings will be planted just before

launch in the rectangular, terrarium-like chambers. All are compact species able to grow in the limited space available and under relatively low light conditions.

Sixteen seedlings will be planted in each chamber, in sandwiches of moist sponge and filter paper. The chambers will be sealed and placed in the Plant Growth Unit which will be loaded late in the launch countdown into a single locker space on the forward bulkhead of the orbiter's mid-deck.

The Plant Growth Unit, which is the size of a filing cabinet drawer, is completely automatic, requiring no flight crew interaction. All data are stored within the experiment package. The unit provides light and temperature control and includes batteries, a tape recorder and controlling electronics.

During the seven-day mission the plants will receive 14 hours daily of artificial sunlight. Researchers will be able to tell from the data whether growth direction varied under light or dark conditions.

Electrophoresis Experiment Verification Test

An experiment which will test the operation of hardware used in separating biological materials on-orbit will be conducted on the third flight of the Space Shuttle.

The Electrophoresis Experiment Verification Test, designed to certify the process of separating cells according to their molecular charge, is part of the Materials Processing in Space Program at the Marshall Space Flight Center, Huntsville, Ala. The hardware was previously flown on the Apollo-Soyuz Test Project in 1976.

The experiment utilizes an electric field to separate cells and other biological materials in a fluid without damaging the cells and is designed to improve the separation of cells for the study of cell biology, immunology and medical research.

Electrophoresis is difficult on Earth because heat produced by the electric field causes buoyancy and re-mixing of the cells and fluid, thereby defeating the process. In space, even though the process still produces heat and density variation in the fluid, the separation is not disturbed because buoyancy is absent in the low gravity environment.

The experiment to be flown on STS-3 consists of an electrophoresis processing unit with glass columns where the separation takes place, camera and film to document the process, and a cryogenic unit to freeze and store the samples after separation. The equipment will be stowed in the mid-deck area of the Shuttle orbiter crew cabin.

One crewman will activate the equipment, insert the biological samples in one of the unit's glass columns and place the columns in the freezer after the experiment is completed. The duration of each separation is one hour.

The samples to be used in the equipment verification test include fixed red blood cells supplied by the Marshall Center and live kidney cells provided by NASA's Johnson Space Flight Center, Houston.

Two televised processing runs will be shown of the red blood cells being separated. The telecasts will provide the principal investigators with the ability to make changes as needed.

The electrophoresis unit will be removed from the orbiter within three hours after landing. The frozen columns will then to be delivered to the Marshall and Johnson Centers for analysis. The flight hardware will be returned to Marshall for refurbishment for planned future Shuttle flights.

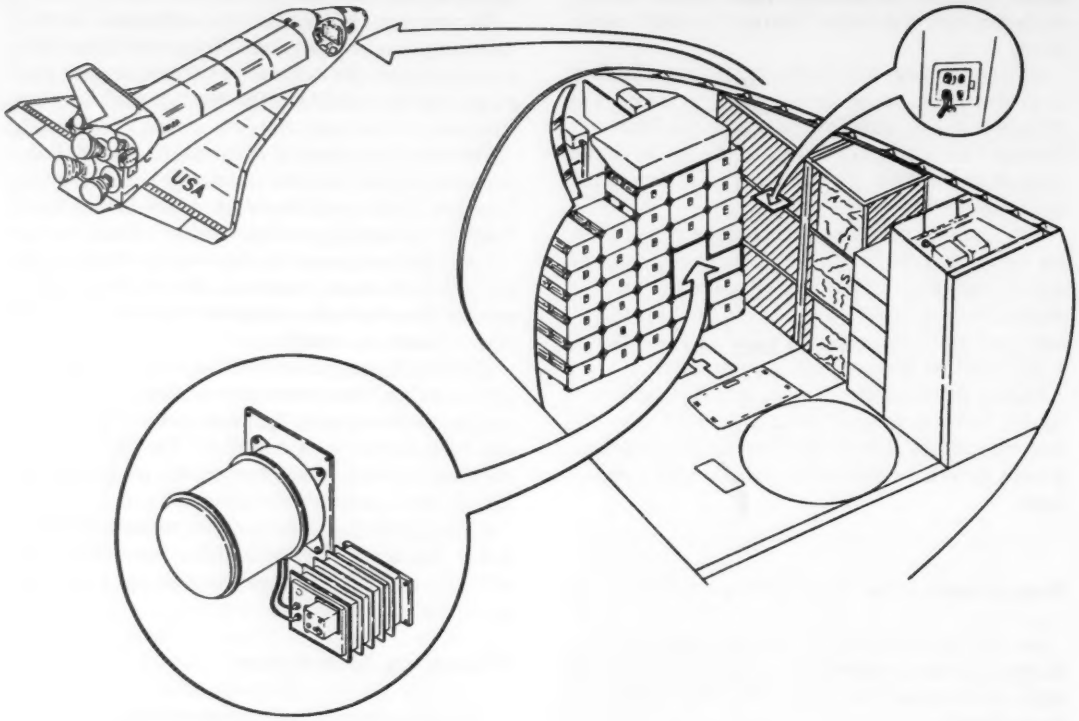
Principal investigators on the experiment are Dr. Robert Snyder at Marshall and Dr. Dennis Morrison at Johnson. The experiment was designed and built by the Marshall Center.

Monodisperse Latex Reactor

The Monodisperse Latex Reactor (MLR) is a materials processing facility which will allow scientists to determine if low gravity will improve the production of large diameter monodisperse (all exactly the same size) latexes. A latex is a suspension of very tiny (micron size-$\approx$0.00004 in.) plastic balls in a liquid, such as water. These latexes have important medical research and industrial applications. However, under Earth's gravity these latexes can only be produced to a size of about 2 microns and still be kept monodisperse. Specifically, the MLR experiment will provide an opportunity to study kinetics of reaction without the effects of buoyance and sedimentation, which affect processing on Earth. It can then be determined and possibly demonstrated that without these complicating factors larger monospheres can be achieved.

The MLR will be used to conduct investigations on a series of four early Shuttle flights. Particles produced on one flight will be used as "seed" for the next flight.

The flight equipment consists of an Experiment Apparatus Container (EAC) and a Support Electronics Package (SEP). The EAC (mass 42.3 kg, size 0.416 m dia. $\times$ 0.495 m high) contains four



Space Shuttle accommodations for the Monodisperse Latex Reactor flown aboard the third flight in March.

separate, independently operated chemical reactors. These reactors are cylinders, wrapped with heating tape, that contain stirrers for agitation and pistons for measuring volume change during reaction.

Each of the reactors will produce latex from 100 cc of the chemical recipe loaded in each. The SEP (mass 13.6 kg, size 0.346 m × 0.265 × 0.300 m) contains a preprogrammed microprocessor which controls the experiment operation after being manually turned on by the crew. The SEP also contains a recorder which stores all data produced during operation of the experiment.

The two components of the flight equipment, the Experiment Apparatus Container (EAC) and the Support Electronics Package (SEP), will occupy the space of three standard mid-deck lockers. Electrical power will be provided to the experiment from an overhead panel in the mid-deck.

The two units will be attached to orbiter wall using adapter plates. Heat produced by the chemical reaction within the MLR reactors will be dissipated passively through the normal air flow in the mid-deck during the 14 hours of operation. Thus, MLR demands on the Shuttles are simple and impose no constraints on the major mission activities.

The ground and flight operations required for MLR are: as follows. First, the four independent reactors inside the EAC will be loaded with appropriate ingredients at the launch site laboratory. When ready for flight, the MLR will be transported to the launch pad and installed in the Shuttle approximately 48 hours before launch. The experiment will be switched on by the crew at any time during a low-gravity period of the mission, will run under the preprogrammed microprocessor control for 14 hours, and will turn itself off. The data generated during the experiment will be recorded on the tape recorder located in the SEP.

The MLR will be removed from the Shuttle at the landing site as soon as possible after landing and returned to the principal investigator for sample and data analysis.

After a cleanup and refurbishment of the flight equipment and loading with a new chemical recipe, the MLR will be ready for another flight.

During the growth phase the latex spheres are required to be kept in a state of suspension, generally achieved through stirring, to avoid "creaming" (floating) at the beginning, and "settling" (sinking) near the end of the process. For very small particles up to 0.5μm ($\approx$ 0.00002 in.) in diameter, the stirring is not necessary. However, for particles of moderate sizes gentle mechanical agitation is required which imposes no problem for earth-bound processing.

Rapid agitation required to keep larger particles in suspension increases the changes of collision between the particles. During growth the particles are spongy and sticky so they deform after collision, do not rebound, and therefore tend to stick together to form clusters of particles. This tendency can be reduced by increasing the quantity of emulsifier, but doing this increases the danger of generating a new crop of particles. This "new crop" of tiny particles also grows along with the seed monodisperse particles and results in a latex with particles of various sizes—therefore, no longer monodisperse.

It is anticipated that the problems encountered with the production of large size particles can be alleviated by carrying out the process in a low gravity environment of space. In space, with the absence of buoyancy and sedimentation, the large size particles will have no tendency to either "cream" or "settle" and could be kept in suspension with no agitation. This would reduce the chance of particle collision which in turn will allow reduction of emulsifier quantity, thereby eliminating the danger of new crop generation.

The experiment will be conducted by Dr. John W. Vanderhoff of Lehigh University as principal investigator along with co-investigators, Fortunato J. Micale and Mohamed S. El-Aasser, also from Lehigh.

The responsibility for providing the MLR flight equipment and testing of the experiment in various phases of development lies with the Materials Processing in Space Project Office and the mission integration activities required to support the MLR flights with the Spacelab Payload Project Office (SPPO), both of NASA's Marshall Space Flight Center, Huntsville.

Induced Environment Contamination Monitor (IECM)

The Induced Environment Contamination Monitor is a desk-sized detector containing 10 instruments for contaminants in and around the Space Shuttle orbiter cargo bay which might adversely affect delicate experiments being carried aboard.

The monitor, developed by the Marshall Space Flight Center, Huntsville, Ala., will be placed in the Shuttle cargo bay on the second, third and fourth missions. It also will be a part of Spacelab missions one and two. It will operate during pre-launch, ascent, on-orbit, descent and post-landing.

With the monitor instrumentation, contaminant sources may be identified and eliminated. It will also provide data on the interaction of the induced and natural environments, and will provide critical data for planning of future Shuttle payloads.

Contaminants to be monitored during Shuttle flights include any outgassing from materials within the Shuttle, as well as gases from the reaction jets which control the vehicle in orbit.

The on-orbit measurements include molecular return flux, background spectral intensity, molecular deposition and optical surface effects. During the other mission phases, dew point, humidity, aerosol content and trace gas will be measured, as well as optical surface effects and molecular deposition.

After each Shuttle flight, the monitor will be returned to Marshall for refurbishment. The flight data will be combined with Orbiter data furnished by the Johnson Space Center, Houston, for a comprehensive analysis.

Catalytic Surface Effects (CSE) Experiment

A strong shockwave encompasses the Shuttle orbiter during the atmospheric reentry maneuver. The shock wave severely compresses and heats the air flowing through it, causing the molecules to dissociate and react chemically with each other.

Computations show that as the dissociated atomic oxygen approaches the cooler regions of flow adjacent to the orbiter, the atomic oxygen fails to recombine into molecular oxygen.

This experiment investigates the chemical reaction caused by impingement of atomic oxygen on the Shuttle thermal protection system. The tiles were designed under the assumption that the atomic oxygen would recombine at the thermal protection system wall. This chemical reaction releases additional heat which results in higher thermal protection

system temperatures. In this case, the surface is referred to as being a catalytic surface allowing the chemical reaction to take place.

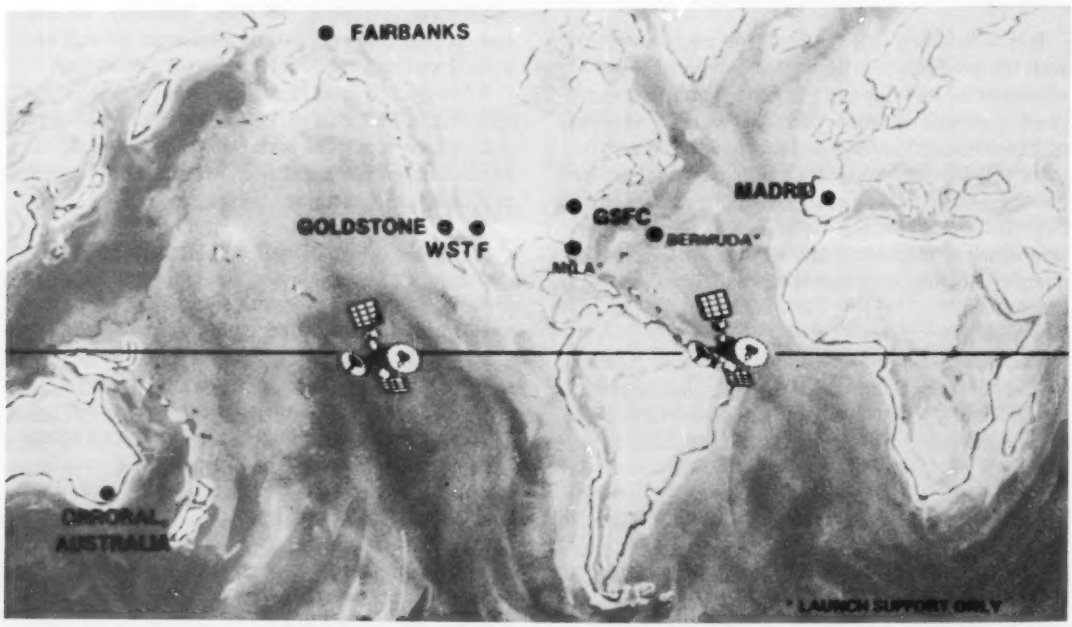
If the thermal protection system surface is non-catalytic, then atomic oxygen will not recombine into molecular oxygen and the heating rates will be lowered. Thus, the temperature of the orbiter during reentry will be lower. With lower temperatures, orbiter thermal protection system weight could be reduced, its flight envelope could be expanded, or greater reusability could result.

The Catalytic Surface Effects uses two baseline tiles, selected from those having development flight instrumentation thermocouples, located on or near the orbiter lower fuselage centerline. These tiles are sprayed with an overcoating mixture of chrome-iron-spinel, a highly efficient catalytic material and a vinyl acetate binder which will protect the overcoat during ground operations. The mixture is compatible with the existing tile and coating and will not alter the thermal or mechanical properties of the uncoated portions of the thermal protection system. During orbiter ascent, the vinyl acetate will burn off the tile surface, leaving the chrome-iron-spinel exposed.

Thermocouple measurements recorded during reentry will be used to determine Catalytic Surface Effects performance. Comparisons of this experiment data with data taken on previous flights from uncoated tiles will aid in the performance evaluation.

Dynamic, Acoustic and Thermal Evironment (DATE) Experiment

Predictions of payload environments will facilitate payload development and reduce the need for ultraconservative design and test. The Dynamic, Acoustic and Thermal Environment experiment will collect information for use in making credible predictions of cargo-bay environments. These environments are neither constant nor consistent throughout the bay and are influenced by interactions between cargo elements. The experiment instrumentation includes accelerometers, microphones, thermocouples and strain gages. Sensor outputs will be recorded for post-flight interpretation. The Goddard Space Flight Center, Greenbelt, Md., will be responsible for the data reduction. Principal technologist is W. Bangs, Goddard.



Improved Shuttle Communications—Artist concept of view of Earth from space showing equatorial on-orbit position of Tracking and Data Relay Satellite System spacecraft. Scheduled for launch in Jan. 1983 aboard orbiter Challenger, these new satellites ultimately will replace more than half the existing ground tracking stations and will provide improved communications to and from the Shuttle and from other Shuttle launches at a greatly reduced cost.

Getaway Special Flight Verification Payload

The purpose of the Getaway Special Flight Verification Payload is to monitor the conditions inside and outside the payload canister. Getaway Specials are small self-contained payloads which will be flown on the Space Shuttle on a space-available basis beginning as early as the STS-4 mission. They are available to industry, educational organizations, and domestic and foreign governments for legitimate scientific purposes. More than 320 have been sold to date.

The standard GAS container is made of aluminum and provides the means of installing small experiments in the orbiter bay as well as protecting the orbiter and crew. The container provides for internal pressure which can be varied from near vacuum to about 1 atmosphere. It also provides thermal protection for the experimental apparatus. The exterior bottom and sides of the container are always thermally insulated. The top may be insulated or not depending upon the specific experiment requirements. An experiment mounting plate provides a solid mounting surface for equipment.

Heflex Bioengineering Test

The Heflex Bioengineering Test is not a full-blown experiment, but a preliminary test in support of a later Spacelab experiment in micro-gravity plant growth. The Spacelab Heflex (for Helianthus annus Flight Experiment) depends on dwarf sunflower plants grown to a particular height range. The test flown on STS-3 will investigate the relationship between plant height and initial soil moisture content in a near weightless environment. Shortly before launch, a suitcase-like container will be loaded aboard Columbia containing 72 sealed plant modules varying in soil moisture content from 58 to 80 percent by weight. The container will be stowed in a locker in the crew compartment and removed unopened as soon as possible after flight for evaluation. Principal investigator is Allan H. Brown of the University of Pennsylvania.

Spacelab Module Unveiled at KSC

Vice President George Bush unveiled the flight module of Spacelab, the Space Shuttle's reusable scientific research facility, at Kennedy Space Center, Fla., on Feb. 5. The participation of Vice President Bush in the unveiling of the European-built Spacelab reaffirmed the Reagan Administration's commitment and support of joint U.S.-European scientific ventures in space.

Spacelab, developed and built under the aegis of the European Space Agency (ESA), is Europe's contribution to NASA's Space Transportation System. It arrived in the United States in December, and a second flight version will be delivered in mid-1982.

Spacelab is a flexible laboratory system that features several interchangeable elements that can be put together in various configurations to meet the particular needs of a given flight. The major elements are a habitable module in which scientists can work in a shirt-sleeve environment and platforms called pallets which can be placed in the Shuttle cargo bay behind the module. These pallets will hold instruments requiring direct exposure to space.

Various configurations of these Spacelab elements can be fitted into the Shuttle to meet the needs of any particular mission. The habitable module can be carried alone, or with one or more pallets. The pallets can also be carried into space on a mission that uses no habitable module. Even when no habitable module is carried, the facility is still called Spacelab.

The module comes in two 4-meter (13.1-foot) diameter segments. The "core segment" houses data processing equipment and utilities for both the pressurized module and pallets when flown together. It also has laboratory fixtures such as air-conditioned experiment racks and a work bench. The second section, called the experiment segment, provides more pressurized work space, additional experiment racks and work benches if needed. The core segment can be flown by itself (called the "short module" configuration), or coupled in tandem with the experiment segment (called the "long module" configuration). The short module, which consists of the core segment and two cone-shaped end sections, measures 4.26 m (15.4 ft) in length. When the two segments are assembled, the maximum outside length, including end cones, is 7 m (23 ft).

The pallets are uniform. Each is a u-shaped platform 4 m (13.1 ft) wide and 3 m (10 ft) long. Heavy items, such as telescopes, are attached to reinforced "hard points" on the pallet's main structure. Lightweight payload equipment can be mounted on the aluminum honeycomb panels that cover the inside of the pallet.

Up to five pallets may be flown on a single mission. When pallets are flown without a habitable

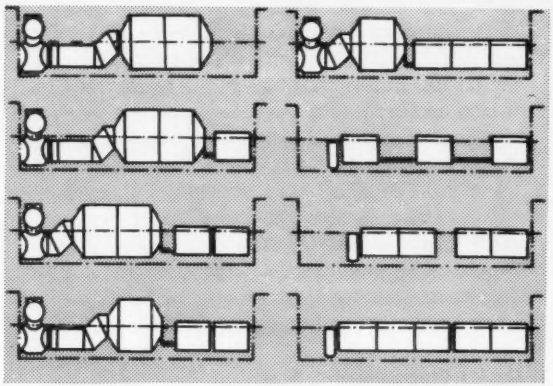
module aboard, subsystems needed for equipment operation (which would normally be housed in the core segment of the module) are placed instead in a pressurized cylinder mounted to the front frame of the first pallet. This cylinder is called the "igloo."

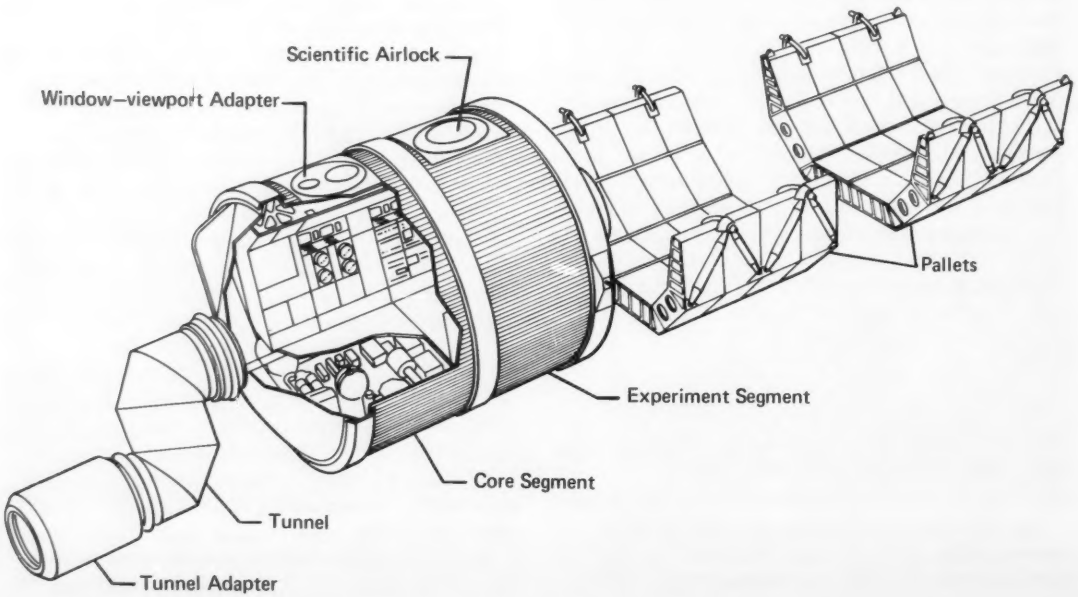
Racks for experiment equipment that goes into the habitable module are also standardized. The 48-centimeter-wide (19-inch) racks can be arranged in single and double assemblies. Normally, the racks and floor are first put together outside the module, checked out as a unit, and then slid into the module where connections are made between the rack-mounted experiment equipment, the subsystems in the core segment, and the primary structure.

Spacelab has other important elements. When a habitable module is flown, an access tunnel about 1 m (3.3 ft) in diameter connects the module with the mid-deck level of the orbiter cabin. The hatch between the cabin and tunnel is left open during a mission, so the Shuttle cabin, tunnel and module all share the same pressure and common air. The tunnel has lighting and handrails to allow easy passage between Spacelab and the Orbiter mid-deck, where the Spacecrew will sleep and take their meals. The length of the tunnel varies with the number of pallets carried behind the habitable module. The more pallets aboard, the further forward the module is carried, hence the shorter the tunnel. Its length ranges from 1.4 m (4.5 ft) to 5.7 m (18.9 ft).

A high quality window-view-port assembly is normally carried in the "ceiling" of either the core segment or experiment segment of the module. A small viewport is permanently mounted in the aft end cone

Spacelab's habitable module and pallets can be configured in several combinations to best support individual mission requirements.





of the module. A scientific airlock may be installed in the overhead area of the experiment segment for use in exposing small instruments to the space environment outside.

The major subsystems of Spacelab include: structure, environment control, electrical power and distribution, command and data management, and common payload support equipment.

The first mission, sponsored jointly and shared equally by NASA and the European Space Agency, is currently scheduled for September 1983. It will feature about 70 separate investigations during seven days in orbit. The Spacelab configuration will consist of the two-segment module and one pallet.

International in nature, Spacelab Mission 1 will have experiments from the United States, Japan, the Netherlands, United Kingdom, Belgium, France, Germany, Italy and Switzerland.

The disciplines represented by these experiments are: atmospheric physics; Earth observations; space plasma physics; materials sciences technology; astronomy; solar physics; and life sciences.

The science crew will consist of two payload specialists, who will operate the experiments with support provided by two mission specialists. Prior to the mission, one American and one European will be selected to actually fly the mission. The others will provide support from the Payload Operations Control Center on the ground. The mission specialists will be astronauts Dr. Owen Garriott and Dr. Robert Parker. The payload specialists selected for Spacelab Mission 1 are:

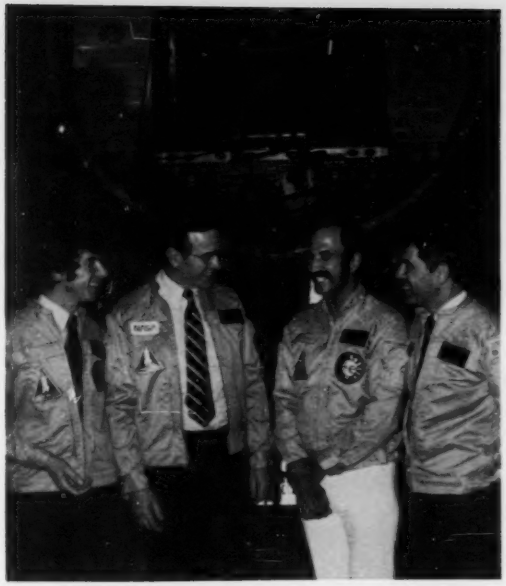
Dr. Michael L. Lampton, a member of the research staff at the Space Sciences Laboratory, University of California at Berkeley. His main fields include astronomy, space physics and optical and electronics engineering.

Dr. Byron K. Lichtenberg of Massachusetts Institute of Technology, who specializes in biomedical engineering.

Dr. Ulf Merbold, staff member at the Max-Planck Institute, Stuttgart, West Germany. His main interests are the study of crystal lattice defects and low-temperature physics.

Dr. Wubbo Ockels, of Groningen University, the Netherlands. He has been involved deeply in nuclear physics experimental investigations.

ESA's prime contractor in the development of Spacelab is the West German firm ERNO Raumfahrttechnik GmbH. Some 50 firms in ESA's 10 participating nations funnel parts to ERNO in Bremen, West Germany, for assembly and integration.



Vice President George Bush taking a tour of the Spacelab hardware in Kennedy Space Center's Operations and Checkout Building. Bush participated in the Spacelab Delivery Ceremony held at Kennedy on Feb. 5. At far left is Ulf Merbold, Spacelab payload specialist, West Germany; second from right, Wubbo Ockels, Spacelab payload specialist, the Netherlands; and at right, Bob Parker, NASA astronaut.

Spacelab is a joint ESA/NASA venture. ESA manages its development with technical support from NASA, while NASA's Marshall Space Flight Center, Huntsville Ala., has prime NASA responsibility for the development in the United States of various flight hardware items such as the transfer tunnel and other ground equipment and facilities to operate the system. Marshall, together with ESA's Spacelab Payload Integration and Coordination in Europe, will manage the first Spacelab mission. Marshall will manage the second and third scientific missions, which are NASA only. The laboratory will be prepared for flight and installed in the Shuttle at Kennedy.

Delivery of the Spacelab to the United States marked a significant step in this program of European-American cooperation in the exploration of space. Under the program, which is costing ESA nearly $1 billion, NASA is receiving at no charge an engineering model and one complete flight version of the laboratory, associated ground support equipment and some computer software. NASA is purchasing a second Spacelab flight unit for approximately $300 million.

Remarks of Vice President George Bush
Spacelab Delivery Ceremony
Kennedy Space Center, Fla.
February 5, 1982

I am very happy to be here with you all today, and I thank you for inviting me to take part in the ceremonies. It seems I turn up at so many Space Shuttle-related events, people are going to start calling me a NASA groupie.

As a matter of fact, I am one. And I hope you keep inviting me back.

I give a lot of speeches these days. This one will be short—you'll no doubt be relieved to hear. I often say, in these speeches, that we're doing our best to bring down the inflation rate, to bring down the interest rates—and that the only thing we want to see going up is the next Space Shuttle.

And now something else will be going up with the Shuttle.

This is a happy day, and an important day. Spacelab, Europe's contribution to the Space Shuttle Program, is an extraordinary engineering achievement. It's also the largest cooperative space project ever undertaken. On behalf of President Reagan and all Americans, I want to congratulate our European partners, especially Dr. Johannes Ortner and Eric Quistgaard, for their fine work.

Spacelab is the fruit of a lot of hard work. Ten member nations of the European Space Agency brought it about. Over two thousand men and women built it. Over fifty European firms participated in the project. Americans can, too, take satisfaction in it. If today can be considered Spacelab's birthday, then there are a great many proud parents celebrating.

You've heard enough about what Spacelab can do—or indeed, you already know enough, since I have a feeling most people here have PhD's in at least one scientific field. Let me just tell you that as a layman, I'm amazed by its potential. Its telescope will look up and out into the outer reaches of space, capturing images of galaxies, of Halley's comet; its cameras will look down on Earth, relaying vital information about crops, pollution, and precious natural resources. In this space laboratory, specialists will work to further our knowledge about vaccines, alloys, pure matter, microwaves . . . and they will try to find a cure for that unique misery of modern age . . . spacesickness.

You all are much more conversant with science than I. So instead, I thought I might offer a comment or two on other, less technical aspects of Spacelab.

Before the first astronauts left the Moon, they left there a plaque that said, "We came in peace for all mankind."

Now man is returning to space once again, this time with all the tools of peace.

And in that connection, I feel very honored today to be able to announce that next flight. The third launch of the Space Shuttle Columbia from Kennedy Space Center has been set for March 22, 1982 at 10:00 a.m.

The crew for that third Shuttle mission is Jack Lousma, Commander, and Gordon Fullerton, Pilot. I know they will continue the unbroken chain of excellence in the performance of their important mission.

Following seven days and three hours in Earth orbit, the Columbia is scheduled to land on the dry lake bed at Edwards Air Force Base, California on March 29.

The knowledge that Spacelab will bring back from its many missions will belong to all mankind.

We are returning to space . . . together, and that is no small achievement. The Space Shuttle and Spacelab represent a bond, not just of transatlantic cooperation and friendship, but of a cooperation and friendship that will extend even beyond the Earth, into the Heavens.

If the Shuttle itself embodies all that is bold and dynamic in the American character, Spacelab symbolizes the unity and determination of free Europe. Together they are a potent symbol, of the interdependence of our nations, and of our partnership.

Let us continue to be partners, in this and in all fields.

And let me take this opportunity to assure you that we intend to continue our international, cooperative programs, just as President Reagan recently reconfirmed the commitment of the United States to a vigorous space program.

"There is beauty in space," said Wernher von Braun, standing on the threshold of the space age in 1958, "and it is

orderly . . . everything in space obeys the laws of physics. If you know these laws, and obey them, space will treat you kindly. And don't tell me man doesn't belong out there. Man belongs wherever he wants to go—and he'll do plenty well, when he gets there."

How far we have come in the last quarter century, and how far we'll go in the next. Spacelab is a claim to the truth of von Braun's boast that we belong wherever we want to go . . . and will prove, I am sure that we'll do plenty well when we get there.

Vice President Bush inside Spacelab in Kennedy's Operations and Checkout Building where the ESA-built orbital laboratory was dedicated Feb. 5. At left is Spacelab mission specialist Ulf Merbold, West Germany; at right is NASA astronaut Owen K. Garriott.

New Saturnian Satellites Discovered

Four, and possibly as many as six, new satellites of Saturn have been found, using data from the Voyager 2 encounter with the planet in August 1981. The discoveries bring the number of known Saturnian satellites to between 21 and 23. The two "possible" satellites were seen in only one observation each, so their orbits are not yet confirmed.

The innermost satellite found by Dr. Stephen P. Synnott of NASA's Jet Propulsion Laboratory, Pasadena, Calif., moves at about the same orbital distance from Saturn as the already-known satellite, Mimas. The object was originally suggested by data from charged-particle instruments aboard Voyager 2. Synnott and Jet Propulsion Laboratory scientist Richard Terrile found the satellite.

A third (and possibly fourth) companion of the satellite Tethys appears to move in what Synnott calls a "horseshoe" orbit. Synnott says that he is sure an object is there, but he is not certain yet, because of resolution limits in the photos, whether it is one or two objects. Satellites in horseshoe orbits trade orbits as they approach each other.

Another satellite was found by Synnott at a point about 60 degrees ahead of the satellite Dione. That is the second found in that region. The first was discovered in Earth-based observations in 1980.

Synnott found yet another satellite about 350,000 kilometers (217,000 miles) from Saturn, between the orbits of Tethys and Dione. It circles Saturn once in 2.44 days.

Synnott's final observation, a faint streak in a Voyager 2 photo, indicates a satellite (the "possible sixth") may exist about 470,000 km (292,000 mi.) from Saturn, between the orbits of Dione and Rhea. Its period of revolution would be, Synnott calculates, 3.8 days.

The object that shares the orbit of Mimas is about 10 km (6 mi.) in diameter. All the others are about 15 to 20 km (9 to 12 mi.) in diameter.

Two Voyager spacecraft were launched in 1977, flew by Jupiter in 1979 and Saturn in 1980 and 1981. Before these encounters, Jupiter was known to have 13 to 14 satellites. Voyager raised the total for Jupiter to at least 16.

Saturn was known to have 10 satellites, but the two Voyagers now have found at least 11 to 13 additional ones.

Voyager 2's next planetary encounter will be with Uranus in 1986. The Voyager project is managed for NASA by the Jet Propulsion Laboratory.

New Venus Discoveries Reported at International Conference

Dramatic new finds about Venus, the Earth's twin planet, were reported at the NASA-University of Arizona-sponsored first International Conference of the Venus Environment, held in Palo Alto, Calif., in November. Several hundred scientists from the United States and other countries attended the Venus conference. Much of the new information comes from data returned by the six Pioneer spacecraft and their 30 experiments. The Pioneers are managed by NASA's Ames Research Center, Mountain View, Calif.

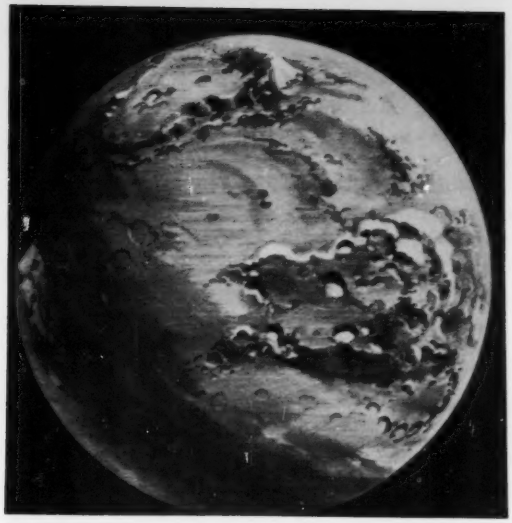
New findings include evidence for two major, currently active volcanic areas on the planet; the probability that these areas are the principal vents for the planet's internal heat; quantified findings that Venus has a thicker crust than Earth and is a "one plate" planet with little plate tectonics; and complete, self-consistent models of Venus' cloud system and greenhouse effect.

Considerable progress has also been made in understanding overall atmosphere circulation (with implications for Earth); and there is strong new evidence for former Venusian oceans on the scale of the Earth's oceans.

Much of the significance of the Venus findings lies in the fact that the Earth and Venus appear to be almost identical copies of each other. Scientists believe the Earth would become a virtual Venus if you stopped its rotation, removed the Moon, and moved our planet slightly closer to the Sun. Therefore, studies of Venus provide a variety of insights into Earth mechanisms.

New Venus discoveries included:

- Apparently there are two major volcanic regions on Venus: Beta Regio and the Scorpion Tail of Aphrodite Terra, largest continent-like upland region on the planet. There is evidence for continuous and current volcanic activity at both places.
- Detailed analysis of Venus' global topography and detailed comparisons with global crustal density (derived from gravity data), show that Venus apparently has a thicker crust than Earth and is a "one plate" planet. Substantial evidence indicates that its crust is not broken into many continent-bearing plates, floating on the liquid interior, as the Earth's crust is.
- Because of its thick, planet-wrapping crust, most of Venus' interior heat appears to come out in its two volcanic regions, unlike Earth. Earth vents its



Artist's concept of Venus' surface showing the planet's three continental-sized highland regions—Aphrodite Terra (foreground), Ishtar Terra (top), and Beta Regio (left) based on topography measurements made by the Pioneer spacecraft.

heat at many points, especially at the constantly expanding mid-ocean ridges. Concentration of Venus' lightning over just two volcanic regions suggests fairly frequent current volcanic activity in both places.

• Though Venus' continents appear not to drift around on crustal plates as Earth's do, crustal density measurements suggest local uplifting of large regions.

This is probably due to up-flowing convective plumes, resulting from circulation of interior magma. The most prominent of these are Aphrodite Terra and Ishtar Terra. Vertical motion of the crust also is suggested by the several deep rift valleys; one, the lowest point on the planet, is at the Scorpion Tail of Aphrodite.

• Beta Regio, a region larger than the Hawaii-Midway chain, appears to be a huge double-shield volcanic construct and is apparently the most active region on the planet. This is shown by variations in crustal density, apparent old lava flows and the region's 6,100-meter (20,000-foot) height and huge size. Beta is believed to sit over a powerful, upflowing convective plume, deep in Venus' interior magma.

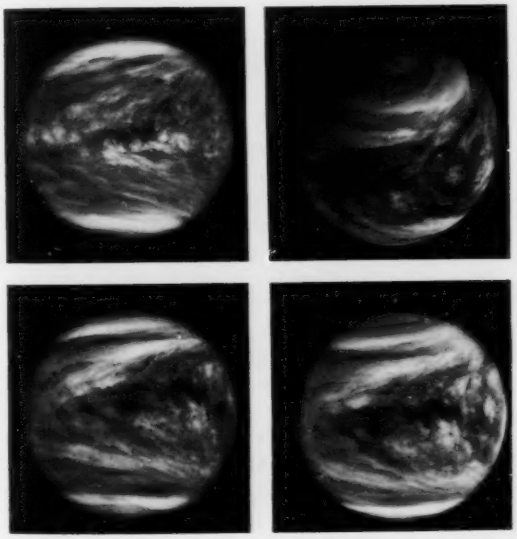
• The new topography data show other smaller volcanoes and one crustal rift 1,500 kilometers (810 miles) long.

• Venus' clouds are "upside down." There's a smog layer on top 15 km (8 mi.) deep, and Earth-like condensation clouds (made of sulfuric acid droplets) below 57 km (31 mi.) extending down to 48 km (26 mi.). These condensation clouds are patchy and vary in density. They produce drizzle but seldom hard rain, and in general are only 10 percent as thick as comparable Earth clouds. Scientists also have now charted and quantified the basic cycle of chemical reactions in the clouds.

• Unlike Earth, which absorbs most solar heat on its surface, Venus absorbs most solar heat in its clouds. In the cloud layer is a single convective circulation cell which carries heat from equator to pole. Earth has three linked major circulation cells transporting heat between equator and poles.

• Venus' cloud region is also a shell of high-speed winds which englobes the planet. Above this wind layer, the atmosphere is almost dead calm. There are two explanations for these high-speed winds on a planet with no rotation.

Both propose wave (eddy)-pumping of the enormous momentum of the planet's dense lower at-



Ultraviolet photos of Venus' clouds selected from 1,000 views of the planet by the Pioneer Venus orbiter spacecraft. Those shown were taken between May 2 and 4, 1980 and cover a period of 38 hours; the planet's clouds circle Venus completely once every 4 days.

mosphere to higher altitudes where the momentum remains. One of these proposed mechanisms involves large horizontal eddies; the other, tidal effects as the lighted hemisphere moves slowly around the planet. Weather theoreticians agree that wave pumping mechanisms are critical to understanding Earth's weather; these mechanisms are not well understood on any planet; and that they have been brought into prominence by recent Venus work.

- Venus appears to have had an ocean and lost it to space. During the solar system's early history (when scientists believe the Sun was 30 percent less hot) Venus' atmosphere and environment could have been Earth-like. Strong evidence for this lost water remains today in the definitive measurement of the ratio of deuterium to hydrogen. (There is 100 times as much deuterium relative to hydrogen on Venus as on Earth. This measurement was found for the first time in the Pioneer data during the recent Venus conference.) With water abundant, the planet may perhaps have sustained life during the early years of solar system's history. When the runway greenhouse effect began, it wiped out most existing phenomena on the planet and replaced them with today's furnace-like environment.

Inspector General Activities

At the request of NASA management officials, NASA's Offfice of the Inspector General initiated efforts to review instances of telephone abuse at a field center. Review of telephone charges identified a NASA employee as having placed over 80 telephone calls to the employee's residence during which time conversations were conducted which totalled approximately 20 hours. The NASA employee probably expected to be billed for the cost of the calls, which did occur. What was not expected was that the employee was charged annual leave for the time spent on the telephone.

As a part of the OIG's comprehensive audit efforts, it was determined that certain policies and procedures used by a NASA contractor for accounting were not adequate to assure proper classification of labor costs. A more in-depth review was scheduled due to the absence of system controls. Mischarging by the contractor in the amount of $3.3 million to the U.S. Government was discovered. Ten percent of the overcharge, $330,000, was directly related to NASA.

The Office of Inspector General urges you to continue your efforts in meeting the challenge of improving NASA programs. Suggestions for eliminating waste and mismanagement are welcome. Identities can be confidential. A 24-hour answering service is available in the Washington, D.C. area on 755-3402 or call (800) 424-9183 (toll-free for all other areas). Please send written suggestions to: NASA Inspector General, P.O. Box 23089, L'Enfant Plaza Station, Washington, D.C. 20024.

Awaiting Launch—Space Shuttle Columbia at Kennedy Space Center's Launch Pad 39A is readied for its third orbital flight; launch is scheduled for March 22.

Space Shuttle Launches for 1982

Orbiter	Launch Date	Launch Site	Payload
Columbia (OV-102)	March 22	KSC	OSS-1
Columbia (OV-102)	July	KSC	DOD 82-1
Columbia (OV-102)	November	KSC	SBS-B, Telesat-E

Expendable Launches for 1982

Name	Launch Date	Vehicle	Range	Mission Remarks
*RCA-C[1]	January 15	Delta	ESMC	RCA communications. Reimbursable.
*Westar-IV	February 25	Delta	ESMC	Western Union communications. Reimbursable.
* Intelsat V-D	March 4	Atlas Centaur	ESMC	Intelsat communications. Reimbursable.
Insat 1A	April 8	Delta	ESMC	India communications. Reimbursable.
NOAA-E/SAR	June	Atlas-73E	WSMC	NOAA/SAR weather. Reimbursable.
Navy 21	June	Scout	WSMC	DOD transit. Reimbursable. Callup.
Intelsat V-E	July	Atlas Centaur	ESMC	Intelsat communications. Reimbursable.
Landsat-D	July	Delta	WSMC	NASA earth resources applications.
Telesat-G (Anik-D1)	August	Delta	ESMC	Canada communications. Reimbursable.
Westar-V	September	Delta	ESMC	Western Union communications. Reimbursable.
RCA-E	October	Delta	ESMC	RCA communications. Reimbursable.
San Marco-D/L	November	Scout	ESMC	International cooperative/Italy.
Intelsat VA-A	December	Atlas Centaur	ESMC	Intelsat communications. Reimbursable.

*Successful launch

Patents for Inventions from NASA Research

The office of General Counsel, NASA Headquarters, announces that the following U.S patents have been issued by the U.S. Patent and Trademark Office to NASA for inventions resulting from NASA research. Inquiries concerning them should be directed to the attention of the NASA Patent Counsel of the indicated installation.

Inventor(s) & Employer	Title	Patent No.	Installation
Hubert C. Vykukal and Bruce Webbon, NASA/ARC	Pressure suit joint analyzer	4,311,055	ARC
Marnell Smith, Victor, W. Katvala and Ernest E. Porter, NASA/ARC	Spray coating apparatus having a rotatable work-piece holder	4,312,292	ARC
E. Thomas Freeman, Charles W. Stump and Francis R. Dreisbach, NASA/LaRC	Film advance indicator	4,311,378	LaRC
Russell T. Crowell, NASA/KSC	System and method for refurbishing & processing parachutes	4,313,291	KSC
Wendell D. Chase, NASA/Ames	Environmental fog/rain visual display system for aircraft	4,313,726	ARC
Gordon F. Lund, National Research Council, Washington, D.C.	Pocket ECG electrode	4,313,433	ARC
John D. Buckley, Robert J. Swaim, Robert L. Fox, NASA/LaRC	One-step dual purpose joining technique	4,313,777	LaRC
James M. Kendall, Jr., Caltech/JPL	Method of forming spheres in a forcefree drop tower	4,313,745	NRO/JPL
Philip A. Studer, NASA/GSFC	Linear magnetic motor/generator	4,315,197	GSFC
Daniel D. Lawson and Gene R. Peterson, Caltech/JPL	Thermochemical generation of hydrogen	4,314,984	NRO/JPL
Denis J. Connolly, NASA/LeRC	Coupled cavity traveling wave tube with velocity tapering	4,315,194	LeRC
Haynes Ellis, Jr., Rockwell International Corp.	Complementary cross-slot phased array antenna	4,315,266	JSC
Reinhold H. Kratzer, Kazimiera J.L. Paciorek . Thomas I. Ito, Ultrasystems Inc., Irvine, Calif., and Robert W. Rosser, NASA/ARC	Preparation of perfluorinated 1,2,4-oxadiazoles	4,316,035	ARC
Thomas Vranas, NASA/LaRC	Hot foil transducer skin friction sensor	4,317,102	LaRC

Another Dividend from Air and Space

Research and development in aeronautics and space have provided numerous benefits for all Americans—and at a tiny percentage of the tax dollar. Here is an example:

Police Communications

When the Oklahoma City Police Department needed a computerized communication system, they turned to NASA technology for assistance—specifically that developed for the Mission Control Center at NASA's Johnson Space Center, Houston.*

Developed in 1960, Mission Control provided entirely new, specially-designed communications, computing and display systems which have been updated over the years. In designing the facility, NASA paid particular attention to the human factors involved in ground management of long duration flights—for example, selection and training of control center personnel; most effective informational displays; and special lighting to reduce controller fatigue and eyestrain.

For the Oklahoma City police communications needs, officials from NASA's Johnson Space Center furnished information on lighting and other fatigue-reducing measures and provided specifications for equipment and design layouts. NASA personnel were particularly helpful in advising how to avoid communications bottlenecks associated with simultaneous handling of telephone, radio and interoffice transmissions.

The use of already-developed NASA technology resulted in a cost savings for the Department in the design and engineering elements of their police communications system.

For each major duty in the Oklahoma City Police Department's communications system there is a computer display console—for each of the four dispatch coordinators and for the telecommunications coordinator, who handles inter-office calls from Department office. Public calls for assistance are received by telephone clerks who have such a terminal at their fingertips. Radio messages—incoming calls and dispatch transmissions—are handled separately by a radio communications coordinator who also is equipped with an individual console.

NASA
National Aeronautics and Space Administration

For the benefit of all . .

*NASA does not endorse commercial products developed as a result of its Technology Utilization or Patent Licensing Programs, but it does encourage the widest possible use of such technology.

*U.S.GOVERNMENT PRINTING OFFICE : 1982 0-361-563/109